Past NASA Program Experiences Enable Future Government & Industry Successes

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NASA Experiences Often Impacted Future Programs

- **Many innovations in rocket engine and vehicle design have their roots in NASA programs**
 - NASA-initiated/developed technologies were made available to US companies
 - Industry often used initial NASA investments, maturing or modifying them as needed to supplement their own efforts

- **There are several benefits to programs and initiatives gaining a start from NASA**
 - The government assumes the initial risk in a new or innovative item
 - Initial expenditure by NASA is indicative to industry of things in which the government might be interested on future proposals
 - Experiences and lessons learned from successes and terminations can be shared broadly with industry and other government entities

NASA Legacy and Future Impacts

- **NASA's historical initiatives covered a wide range of constructs**
 - Programmatic considerations
 - Design Considerations and Emphasis
 - Technology maturation and infusion

- **Many lessons have been and continue to be learned from NASA investments**



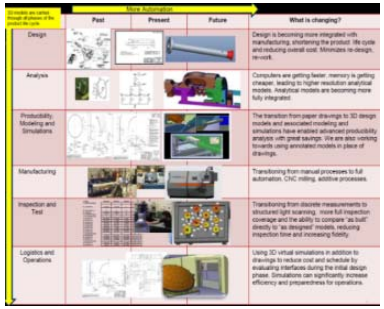




NASA experiences can provide a foundation for the future

Additive Technology: Parallel DDT&E and Materials Efforts Rapidly Advance Understanding

Defining the Development Philosophy for the Future





Bridging the gap between the present and future projects

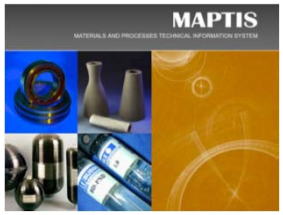


Building Experience / "Smart Buyer"



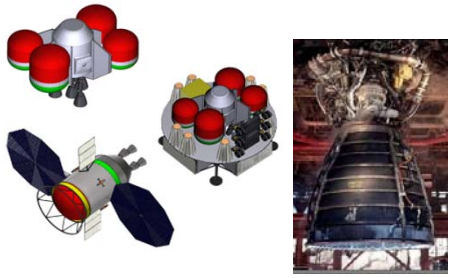
Advancing the Technology Readiness for Complex Parts

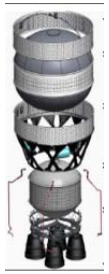




Transferring Material Property Data & Technology to U.S. Industry

Paving the way for Future Affordable Systems



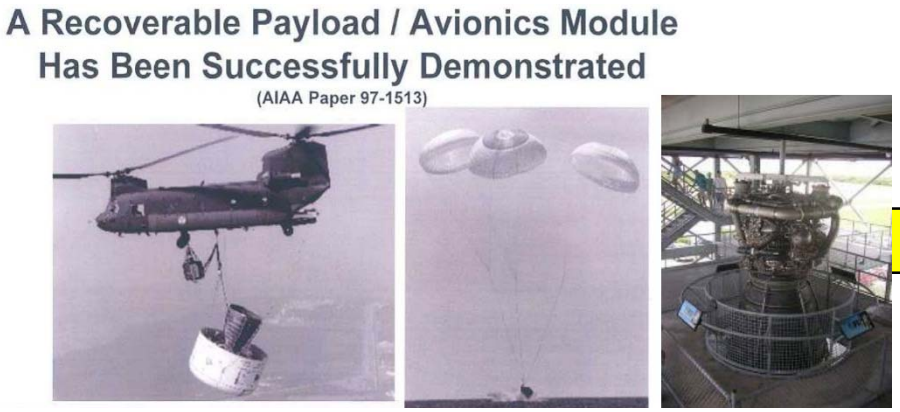


Fundamental Additive Manufacturing M&P Development

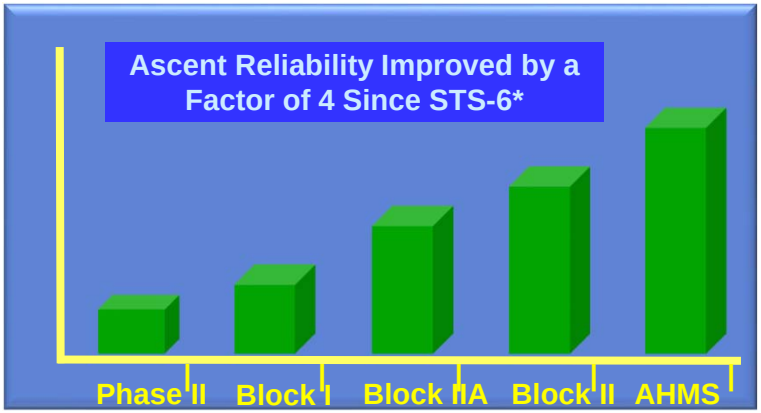
Push → Material Properties & Non-Destructive Evaluation → Standards & Specifications → Certification Rationale → **Pull**

Reusability Debate and Shuttle Lessons Learned

- **Shuttle provided a wealth of data from the beginning of the program to the end to better understand reusability, its benefits, and its costs**



SSME Successfully Tested after Recovery



- **There are many benefits to reusability of launch vehicles and/or engines**
 - Positive influence on design
 - Increase in reliability over time
- **The benefits of reusability come at a cost**
 - More expensive and challenging to design and build
 - Significant challenge to recoup the costs associated with reusability

* Reference: AIAA-2011-7159 "Space Shuttle Main Engine — The Relentless Pursuit of Improvement" by Van Hooser & Bradley

Relevance to Current and Future Programs

- **Significant Investments are being made in Additive Manufacturing**
 - Space Launch System Engines Element is investigating using additively manufactured parts on new RS-25 engines
 - Commercial Crew Providers are planning to fly additively manufactured parts
 - Aircraft Industry is just one of many US industries to invest in additive for the future
- **Several entities are currently considering reusability for their flight programs**
 - Space Exploration Technologies (SpaceX)
 - Falcon 9 recovery of the core stage
 - Falcon Heavy recovery of two boosters
 - Airbus recovery of the engine compartment from their Adeline (Advanced Expendable Launcher with Innovative Engine Economy) vehicle
 - United Launch Alliance (ULA) recovery of Blue Origin BE-4 engines from Vulcan rocket

We Must Continue to Share Experiences and Lessons Learned To Enable Future Successes